Claims

What is claimed is:

1. An apparatus, comprising:

a die;

a heat spreader mounted adjacent the die;

a thermal interface material interposed in a gap between the die and the heat spreader; the thermal interface material comprising an array of carbon nanotubes; and

at least one buffer layer disposed between the thermal interface material and at least one of either the die or the heat spreader.

2. The apparatus of claim 1, wherein selected carbon nanotubes of the array of carbon nanotubes are bonded to adjacent carbon nanotubes of the array of carbon nanotubes.

3. The apparatus of claim 1, wherein a buffer layer is interposed between the interface material and the die.

4. The apparatus of claim 1, wherein the buffer layer comprises a metal.

5. The apparatus of claim 1, wherein a portion of at least some carbon nanotubes of the array of carbon nanotubes are coated with metal.

6. The apparatus of claim 3, wherein the buffer layer comprises a film selected from the group consisting of Cr, Mo, Ti, SiC and TiC.

7. The apparatus of claim 1, wherein a buffer layer is interposed between the thermal interface material and the heat spreader.

8. The apparatus of claim 7, wherein the buffer layer comprises a catalyst for carbon nanotube growth selected from the group consisting of at least one of Co, Fe and Ni.

9. The apparatus of claim 1, wherein the length of at least some of the carbon nanotubes slightly exceeds the width of the gap.

10. The apparatus of claim 1, wherein a surface of the heat spreader is formed from a material having a hardness substantially less than that of the nanotubes and free ends of at least some of the carbon nanotubes project from the array of carbon nanotubes to embed them in the surface of the heat spreader.

11. The apparatus of claim 10, wherein the surface is a coating.

12. The apparatus of claim 1 wherein the length of some of the carbon nanotubes exceeds a predetermined gap by a distance established by the height of a spacer inserted in the gap.

13. An apparatus, comprising:

an array of carbon nanotubes interposed between a die and a heat spreader, a longitudinal axis of some of the carbon nanotubes substantially commonly oriented and aligned substantially perpendicular to a surface of either at least one of the die or the heat spreader; and

a buffer layer formed between the array and a surface of either the die or the heat spreader.

14. The apparatus of claim 13, wherein the buffer layer consists of a film selected from the group consisting of Cr, Mo, Ti, W, SiC and TiC.

15. The apparatus of claim 13, wherein the length of some of the carbon nanotubes exceeds a predetermined gap by a distance established by the height of a spacer inserted in the gap between the die and the heat spreader.

16. A computing system, comprising:

a die including a die surface and a circuit electrically coupled to the wireless transceiver;

a heat sink; a thermal intermediate interposed between the die surface and the heat sink and having an array of carbon nanotubes and at least one buffer layer coupled to the array of carbon nanotubes and at least one of the heat sink and the die surface; and

at least one dynamic random access memory device.

17. The system of claim 16, wherein the circuit comprises a processor that acts upon data signals, and may include, for example, a microprocessor.

18. The system of claim 16, wherein the buffer layer comprises a metal.

19. A method, comprising:

coupling a heat source to a first surface of an array of substantially aligned carbon nanotubes;

interposing a layer between at least one of either the heat source or a heat sink and at least one of either the first or a second surface of the array of carbon nanotubes; and

coupling a surface of the heat sink to the second surface of the array of carbon nanotubes.

20. The method of claim 19, wherein coupling a surface of the heat sink to the second surface of the thermal interface material comprises forming a layer

on the heat sink and growing the array of substantially aligned carbon nanotubes on the layer.

21. The method of claim 19, wherein coupling the heat source to a first surface of an array of substantially aligned carbon nanotubes comprises applying an adhesion promoting layer between the heat source and the array of carbon nanotubes.

22. The method of claim 19, also comprising bonding the other surface of the heat source to a substrate.

23. A method, comprising:

growing an array of substantially aligned carbon nanotubes from a surface of a heat sink; and

contacting the surface of a die with free ends of some of the carbon nanotubes of the array of carbon nanotubes.

24. The method of claim 23 also comprising forming an adhesion layer on the surface of the die.

25. The method of claim 23 also comprising forming an adhesion layer on some of the carbon nanotubes of the array of carbon nanotubes.

26. A method, comprising:

coupling a heat sink to a first surface of an array of carbon nanotubes;

applying an adhesion promoting coating to at least one of either the surface of a heat source or some of the carbon nanotubes of the array of carbon nanotubes; and

coupling the heat source to a second surface of the array of carbon nanotubes.

27. The method of claim 26, wherein applying an adhesion promoting coating comprises applying a metal.

28. The method of claim 26, wherein applying an adhesion promoting coating to some of the carbon nanotubes of the array of carbon nanotubes comprises sputtering a metal coating on the carbon nanotubes.

29. The method of claim 26, wherein applying an adhesion layer to the heat sink comprises applying a chemical adhesion promoting layer.